Introduction

Environmental Conditions

Acid drainage from abandoned underground and surface coal mines and coal refuse piles is the most chronic industrial pollution problem in the Appalachian Coal Region of the Eastern United States. It has been estimated that, as of 1998, there are currently over 1.1 million acres of abandoned coal mine lands, over 9,709 miles of streams polluted by acid mine drainage (AMD), 18,000 miles of abandoned highwalls, 16,326 acres of dangerous spoil piles and embankments, and 874 dangerous impoundments (IMCC, 1998; Lineberry and others, 1990; OSMRE, 1998). Prior to the passage of the federal Surface Mining Control and Reclamation Act (SMCRA) of 1977 reclamation of mining sites was not a federal requirement and therefore, often was not done. However, some states did have reclamation requirements prior to 1977. Of the land disturbed by coal mining between 1930 and 1971, roughly only 30 percent has been reclaimed (Lineberry and others, 1990). Ninety percent of AMD comes from abandoned coal mines (mostly underground mines) where no individual or company is responsible for treating the water (Skousen and others, 1999).

One of SMCRA's goals was to promote the reclamation of mined areas left without adequate reclamation prior to the enactment of SMCRA and which continue, in their unreclaimed condition, to substantially degrade the quality of the environment, prevent or damage the beneficial use of land or water resources, or endanger the health or safety of the public.

Waters Impacted by Pre-SMCRA Mining

Problematic mine drainage forms when air and water come into contact with certain minerals in rocks associated with mining. Pyrite and other sulfide minerals in rocks associated with coal react with oxygen and water to form acid and yield dissolved metals (such as aluminum, iron, and manganese). The acidity and dissolved metals then contaminate surface and ground water. The production of acid mine drainage can occur during several phases of the mining process, and can continue well after the mine has closed. In Great Britain, for example, Roman mine sites dating back 2,000 years continue to generate acid mine drainage today (USGS, 1998).

Streams that are impacted by acid mine drainage characteristically have low pH levels (less than 6.0, standard units) and contain high concentrations of sulfate, acidity, dissolved iron, and other metals. These conditions commonly will not support fish or other aquatic life. Even if the acid is neutralized (pH raised), the metals will precipitate and coat the stream bed, making it unsuitable for supporting aquatic life. Additionally, the impact of mine drainage on the waterway aesthetics results in undesirable conditions for visitors and recreational users (EPA Region III and OSM, 1997).

Acid mine drainage can result from both surface and underground coal mining and from coal refuse piles. In surface mining, the rock overlying the coal (overburden) is excavated, and in the process, broken into a range of large to small rock fragments that are replaced in the pit after the coal is removed. This exposes the acid-forming minerals in some rocks to air and water resulting in a high probability of AMD formation, if such minerals are present in sufficient quantities. In underground mining, large reservoirs of AMD may form in the cavern-like passageways below the earth surface. These reservoirs are constantly replenished by ground-water movement through the mineral-bearing rocks, creating more AMD. Water from these “mine pools” seeps through hillsides or flows freely from abandoned mine entries, enters streams, and deposits metal-rich precipitates on the substrate downstream. Coal refuse piles often contain excessive amounts of pyritic materials, and water flowing through the piles can become highly acidic.

Mine drainage discharges can be as small as an unmeasurable flow, or they may be huge torrents of thousands of gallons per minute. Receiving streams frequently do not contain sufficient alkalinity to neutralize the additional acid, thus its water quality may be adversely impacted and the stream’s uses impaired. Even if the stream has sufficient alkalinity to improve pH, precipitation of iron, manganese, and/or aluminum may occur.

303(d) List

Pursuant to Section 303(d) of the Clean Water Act, States biannually submit a list of water bodies not presently supporting designated uses to the U.S. Environmental Protection Agency (EPA). As required by 40 CFR 130, 7(b)(4), States biannually compile a 303(d) list of streams affected by such pollution sources as acid mine drainage. Priority and non-priority stream lists are generated on the basis of analytical and benthic investigations. Acid mine drainage impacts approximately 9,709 stream miles (IMCC, 1998). Table 1 contains a summary of the stream miles affected by AMD, according to the 1998 303(d) lists for each state.

Table 1: Number of Stream Miles Impacted by AMD

State	Stream Miles (Source A)	Stream Miles (Source B)	Stream Miles (Source C)*
Alabama	65	--	50+440 acres
Illinois	NA	--	--
Indiana	0	--	--
Kentucky	600	--	141+219 acres
Maryland	430	152	--
Missouri	139	--	--
Ohio	1,500	607	--
Pennsylvania	3,000	3,239	2,149
Tennessee	1,750	--	726+ 510 acres
Virginia	NA	17	44
West Virginia	2,225	1,100	2,019
Totals	**>9,709**	**>5,115**	**>5,129 + 1,169 acres**

* May include area of affected lakes and reservoirs
Source A: IMCC, 1998
Source B: Faulkner & Skousen, 1998
Source C: State 303(d) lists, 1998.
NA = Not Available

Abandoned Mine Land Program and AMLIS

Title IV of SMCRA established the Abandoned Mine Land (AML) program, which provides for the restoration of eligible lands and waters mined and abandoned or left inadequately restored. The AML program stipulates that a tax of $0.35 per ton of surface mined coal, $0.15 per ton for underground mined coal, and $0.10 for lignite coal be paid into the AML fund. These funds are deposited in an interest-bearing Abandoned Mine Reclamation Fund which is used to pay reclamation costs of AML projects. When Congress passed SMCRA, it realized that AML fees would not generate enough revenue to address every eligible site, and it left the States and Indian Tribes the choice of which projects to select for funding.

Expenditures from the AML fund are authorized through the regular congressional budgetary and appropriations process. SMCRA specifies that 50 percent of the reclamation fees collected in each state be allocated to that State for use in its reclamation program. SMCRA further specifies that 50 percent of the reclamation fees collected annually with respect to Indian lands be allocated to the Indian tribe having jurisdiction over such lands, subject to the Indian tribe having eligible abandoned mine lands and an approved reclamation plan. The remaining 50 percent is used by the Office of Surface Mining Reclamation Enforcement (OSMRE) to fund emergency projects and high-priority projects in states and Indian tribes without approved AML programs under the Federal Reclamation Program (FRP); to fund the Rural Abandoned Mine Program (RAMP); to fund the Small Operator Assistance Program (SOAP); to supplement the State-share funding for reclamation of abandoned mine problems through State/Indian tribe reclamation programs; and for Federal expenses to collect the AML fee and administer the AML program.

The Office of Surface Mining's Abandoned Mine Land Inventory System (AMLIS) catalogs AML areas by problem type and estimated reclamation cost. The most serious problems are those posing a threat to health, safety, and general welfare of people (Priority 1 and Priority 2, or "high priority"). These are the only problems which the law requires to be inventoried. The 17 Priority 1 and 2 types are:

- Clogged Streams
- Clogged Stream Lands
- Dangerous Highwalls
- Dangerous Impoundments
- Dangerous Piles & Embankments
- Dangerous Slides
- Gases: Hazardous/Explosive
- Hazard. Equip. & Facilities
- Hazardous Water Bodies
- Ind./Residential Waste
- Portals
- Polluted Water: Agri. & Ind.
- Polluted Water: Human Consump.
- Subsidence
- Surface Burning
- Underground Mine Fires
- Vertical Openings

AML problems impacting only the environment are known as Priority 3 problems. While SMCRA does not require OSMRE to inventory every unreclaimed Priority 3 problem, some states and Indian Tribes have chosen to submit such information. There are 12 Priority 3 problem types in AMLIS and they are:

- Benches
- Industrial/Residential Waste
- Equipment/Facilities
- Gob
- Highwalls
- Haul Road
- Mine Openings
- Slump
- Pits
- Spoil Areas
- Slurry
- Other

Of the $3.6 billion of high priority (Priority 1 and 2) coal-related AML problems in the AML inventory, $2.5 billion, or 69 percent, have yet to be funded and reclaimed. Priority 1 and 2 AML problems are those that pose a significant health and safety problem, and does not include environmental problems such as AMD. Estimates as of 1998 indicate that ninety percent of the $1.7 billion coal related environmental problems (Priority 3) in the AML inventory are not funded and reclaimed (OSMRE, 1999). An important note is that the AMLIS Priority 3 inventory represents only a small part of the total environmental problem as states are not required to inventory Priority 3 problems in general. In addition, the AML inventory is more complete for some states than for others, and the frequency of occurrence of different types of problems varies widely between states. Table 2 lists inventories of abandoned mine land conditions in nine Eastern Coal Region states.

Table 2: AML Inventory Totals of 4 Major AML Problem Types in Appalachia and the U.S., as of September, 1998 (OSMRE, 1998)

State	Clogged Stream Lands (acres)	Dangerous Highwalls (linear feet)	Dangerous Piles or Embankments (acres)	Dangerous slides (acres)
Alabama	0	177,945	2,209	21
Indiana	0	1,650	25	0
Kentucky	7,936	64,718	1,137	1,519
Maryland	5	8,250	156	8
Ohio	11,850	56,453	29	99
Pennsylvania	570	1,116,071	5,294	7
Tennessee	0	36,560	779	92
Virginia	1,717	91,889	154	117
West Virginia	164	1,358,616	1,928	346
Appalachia Total	22,242	2,912,152	11,711	2,209
% of U.S. Total	93%	68%	72%	98%
U.S. Total	24,028	4,252,115	16,282	2,253

The cost of remediating AML problems far exceeds the amounts that may ever be collected; hence, alternative solutions should be found to reclaim remaining AML sites. AML funds fall far short for may states, especially for those that were extensively mined prior to SMCRA. For example, in Virginia, an estimated $432 million in Priority 1, 2, and 3 AML liabilities remain while annual funding in recent years has been on the order of $5 million (Zipper and Lambert, 1998). At current rates, it will take better than 80 years to reclaim Virginia's abandoned mine land problems.

Remining can be one of the tools used to help the AML funding shortfall. A report by Skousen and others (1997) compared the cost of remining ten sites in Pennsylvania and West Virginia to the costs of reclamation to AML standards. All ten remining operations resulted in environmental benefits. In all but two cases, the coal mined and sold from the remining operation produced a net profit for the remining company. Remining of these ten sites saved the AML program over $4 million (Skousen and others, 1997).

Industry Profile

The U.S. coal mining industry has its commercial roots back to approximately 1750 when coal was first mined from the James River coalfield near Richmond Virginia. More recently, U.S. coal production set record levels in 1997, when a record 1.09 billion short tons were mined. The electric power industry used a record 922 million short tons (85 percent of coal mined) that year. The three highest ranking coal producing states in 1997 were Wyoming (26 percent), West Virginia (16 percent), and Kentucky (14 percent), which together accounted for 56 percent of the coal produced in the United States (DOE, 1997).

Estimates available as of 1997 on coal production by state in the U.S. are summarized in Table 3. In 1996, the Energy Information Administration estimated that the United States has enough coal to last 250 years (USGS, 1996). They estimated that the demonstrated reserve base of coal in the United States was 474 billion short tons. Although recoverability rates differ from site to site, an estimated 56 percent (or 265 billion tons) of the demonstrated reserve base is presently recoverable (DOE, 1999).

Regulatory History

On October 13, 1982, EPA promulgated final effluent guidelines under the Clean Water Act to limit the discharges from the coal mining industry point source category. The rule amended previously promulgated effluent limitations guidelines based on “best practicable control technology currently available” (BPT) and “new source performance standards” (NSPS), and established new guidelines based on “best available technology economically achievable” (BAT).

Table 3: Coal Production by State (Short Tons) (DOE, 1997)

State	Underground	Surface	Total	Mines
Alabama	18,505,000	5,963,000	24,468,000	51
Alaska	--	1,450,000	1,450,000	1
Arizona	--	11,723,000	11,723,000	2
Arkansas	--	18,000	18,000	3
Colorado	17,820,000	9,628,000	27,449,000	14
Illinois	34,824,000	6,334,000	41,159,000	28
Indiana	3,530,000	31,967,000	35,497,000	39
Kansas	--	360,000	360,000	3
Kentucky	96,302,000	59,551,000	155,853,000	529
Louisiana	--	3,545,000	3,545,000	2
Maryland	3,301,000	859,000	4,160,000	18
Missouri	--	401,000	401,000	4
Montana	8,000	40,997,000	41,005,000	8
New Mexico	--	27,025,000	27,025,000	6
North Dakota	--	29,580,000	29,580,000	6
Ohio	16,949,000	12,205,000	29,154,000	81
Oklahoma	212,000	1,409,000	1,621,000	11
Pennsylvania				
Anthracite	419,000	4,259,000	4,678,000	131
Bituminous	54,410,000	17,110,000	71,520,000	272
Tennessee	1,396,000	1,904,000	3,300,000	27
Texas	--	53,328,000	53,328,000	12
Utah	26,683,000	--	26,683,000	12
Virginia	26,929,000	8,907,000	35,837,000	191
Washington	--	4,495,000	4,495,000	3
West Virginia	116,523,000	57,220,000	173,743,000	349
Wyoming	2,846,000	279,035,000	281,881,000	25
Appalachian Total	**308,360,000**	**159,418,000**	**467,778,000**	**1,602**
Interior Total	**64,941,000**	**105,923,000**	**170,863,000**	**149**
Western Total	**47,357,000**	**403,934,000**	**451,291,000**	**77**
East of Miss. River	**373,089,000**	**206,281,000**	**579,369,000**	**1,716**
West of Miss.	**47,569,000**	**462,994,000**	**510,563,000**	**112**
U.S. Total	**420,657,000**	**669,274,000**	**1,089,932,000**	**1,828**

The October 1982 rule established four subcategories for promulgation of effluent limitations based on BAT: (1) preparation plants and associated areas; (2) acid mine drainage; (3) alkaline mine drainage; and (4) post-mining discharges. The limitations of acid mine drainage, post-mining discharges at underground mines, and coal preparation plants and associated areas were based on neutralization and settling technologies. The limits for alkaline mine drainage were based solely on settling technology. For the coal mining category, BAT and BPT effluent limits were identical.

The issue of remining was raised during the comment period following the 1982 proposal of the final rule. Comments addressed the fact that technology-based standards would likely serve as a deterrent to remining activities, since the operator would have to assume responsibility for treating effluent from previous operations that already may be significantly contaminated. However, the question of the appropriate effluent limitations for remining operations was not a subject of the proposal, and was therefore not addressed in detail in the final rule. Instead, EPA stated that generally, effluent limitations guidelines and standards are applicable to point source discharges even if those discharges pre-dated the remining operation.

In 1987, the Clean Water Act (CWA) was amended to provide incentives for remining abandoned mine lands that were mined prior to the 1977 passage of the Surface Mining Control and Reclamation Act (SMCRA). The modification of the CWA (known as the Rahall Amendment) established that BAT effluent limitations for iron, manganese, and pH are not required for discharge conditions existing prior to remining activities.

Remining

Development of modern surface-mining techniques has allowed for more efficient and effective removal of coal deposits; consequently, mining is now feasible in areas where mining was previously uneconomical. A report prepared for the U.S. Department of Energy estimates that

460 million to 1.1 billion tons of coal could potentially be recovered from remining in mine states (PA, WV, MD, VA, KY, TN, OH, IN, IL) (Veil, 1993).

In 1987, Congress passed the "Rahall Amendment" to the Clean Water Act. The CWA was amended to include section 301(p) in order to provide remining incentives for permits containing abandoned mine lands that pre-date the passage of SMCRA in 1977. The Rahall Amendment established that BAT effluent limits for iron, manganese, and pH (40 CFR part 434) are not required for pre-existing mine drainage discharges. Instead, site-specific BAT limits determined by Best Professional Judgement (BPJ) are applicable to these pre-existing discharges, and the permit effluent limits for iron, manganese, and pH (or acidity) may not exceed pre-existing "baseline" levels. The Rahall Amendment established new effluent guidelines for pre-existing discharges for remining operations potentially freeing the operators from the requirement to treat degraded pre-existing discharges to the statutory BAT levels. "Remining," as defined in the 1987 Rahall Amendment and this document, refers to a coal mining operation which began after the enactment of the Rahall Amendment at a site on which coal mining was conducted before the effective date of the Surface Mining Control and Reclamation Act of 1977.

On September 3, 1998, the Interstate Mining Compact Commission (IMCC) distributed a Solicitation Sheet to member states in support of continuing efforts to collect data and information required for proposal of a remining subcategory under 40 CFR 434. The solicitation sheet was intended to gather information necessary to assess current industry remining activity and potential. The results of the solicitation are summarized in numerous tables in this report.

IMCC member states have estimated that there are currently 150 mining companies in ten states actively involved in remining activities. These companies are producing at least 25.1 million tons of coal annually; and employing approximately 3,000 people (Table 4). As of 1998, there were approximately 1,072 active remining permits and 638 AML projects, (Table 5). Of these 1,072 permits, 330 (31 percent) are Rahall-type permits where the effluent standards for pH, iron, and manganese have been relaxed.

Table 4: State by State Profile of Remining Operations (IMCC, 1998)

	Number of mining companies with remining permits	Total employment at remining operations (Number of employees)	Annual coal production from remining sites (tons)	Estimated coal reserves (tons)
Alabama	20	ND	ND	ND
Alaska	0	0	0	0
Colorado	0	0	0	ND
Illinois	35	70	200,000	10,000,000
Indiana	2	NA	720,000	NA
Kentucky	4	ND	ND	ND
Maryland	13	150	650,000	ND
Missouri	2	0	0	ND
Mississippi	0	0	0	ND
Montana	0	--	--	--
New Mexico	0	0	0	0
Ohio	3	ND	ND	ND
Pennsylvania	50	2,345	17,530,000	100,000,000+
Tennessee	10	75 - 100	3,000,000	50,000,000
Texas	0	0	0	0
Utah	0	0	0	ND
Virginia	3	300	3,000,000+	ND
West	8	ND	ND	ND
Wyoming	0	0	0	ND
Totals	**150**	**>2,940-2,965**	**>25,100,000**	**>160,000,000**

NA = Not Available; -- = No Response; ND = No Data.

Table 5: Types of Remining Permits Issued by State (IMCC, 1998)

State	Number of Rahall Permits	Number of Non-Rahall Permits (a)	"Other" Remining Permits/Projects (b)	Remining Permits (% of Total)
Alabama	10	61	1	ND
Alaska	0	0	0	0
Colorado	0	0	15	0
Illinois	0	41	0	0
Indiana	0	1	1	1
Kentucky	4	N/A	1	40
Maryland	2	21	0	30
Missouri	0	20	0	15
Mississippi	0	0	0	0
Montana	0	0	14	0
North Dakota	0	--	--	--
New Mexico	0	--	--	0
Ohio	3	ND	101	60-70
Pennsylvania	300	40	3	95(c)/50(d)
Tennessee	0	350-450	0	60
Texas	0	0	0	0
Utah	0	0	0	0
Virginia	3	158	501	75-80
West Virginia	8	--	1	0.4
Wyoming	--	--	--	--
Totals	**330**	**692-792**	**638**	

(a) Where operators accept liability for all discharges.
(b) (e.g., AML)
(c) Anthracite
(d) Bituminous

N/A = Not Applicable
-- = No Response
ND = No Data

Table 6 provides information on the type of remining being conducted at the existing remining operations (i.e., refuse piles, surface mine, or underground mines).

Table 6: Characteristics of Existing Remining Operations by State (IMCC, 1998)

	Number of coal refuse piles		Number of surface mine sites		Number of underground sites		Number of remining permits meeting BAT	
State	**Active Mines Under Permit**	**AML Projects**	**Active Mines Under Permit**	**AML Projects**	**Active Mines Under Permit**	**AML Projects**	**Active Mines Under Permit**	**AML Projects**
Alabama	4	1	54	--	13	--	ND	1
Alaska	0	0	0	0	0	0	0	0
Colorado	0	4	0	12	0	2	0	0
Illinois	40	0	1	0	0	0	0	0
Indiana	1	0	34	--	2	--	0	--
Kentucky	3	1	1	--	2	--	5	--
Maryland	0	--	17	--	21	--	2	--
Missouri	0	0	2	0	0	0	0	0
Mississippi	0	0	1	0	0	0	0	0
Montana	1	--	11	--	1	--	0	--
New Mexico	0	0	0	0	0	0	0	0
Ohio	0	--	2	1	1	--	0	--
Pennsylvania	173	0	1,278	0	655	2	616	0
Tennessee	5-10	0	135-180	0	210-260	0	0	0
Texas	0	0	0	0	0	0	0	0
Utah	5	0	2	0	32	N/A	0	N/A
Virginia	33	38	77	117	107	104	0	2
West Virginia	1	--	7	--	1	--	9	--
Wyoming	--	--	--	--	--	--	--	--
Totals	**266- 271**	**44**	**1,622-1,667**	**130**	**1,045-1,095**	**108**	**632**	**3**

N/A = Not Applicable; -- = No Response; ND = No Data.

Best estimates of potential remining activities according to IMCC member states are provided in Table 7.

Table 7: Potential Remining Operations by State (IMCC, 1998)

	Number of coal refuse piles	Number of surface mine sites	Number of underground mined sites
Alabama	1	--	--
Alaska	3	5	1
Colorado	~400	~50	~850
Illinois	30	10	12
Indiana	150	453	615
Kentucky	~200	400-600	800 - 1,000
Maryland	10	75	75
Missouri	0	0	0
Mississippi	0	1	0
Montana	1	11	1
New Mexico	N/A	N/A	N/A
Ohio	(1,095 acres)	(23,000 acres)	4,000
Pennsylvania	858	(158,960 acres)	(31,587 acres)
Tennessee	(182 acres)	(46,000 acres)	800
Texas	0	0	0
Utah	5	2	32
Virginia	400-450	750	800
West Virginia	--	3	--
Wyoming	0	0	0
Totals	**2,058 - 2,108 and 1,277 acres**	**1,760 - 1,960 and 227,960 acres**	**7,986 - 8,186 and 31,587 acres**

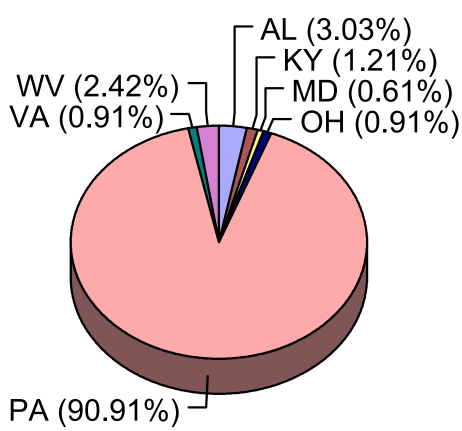
-- = No Response; N/A = Not Applicable

Existing State Remining Programs

After more than ten years of success with state remining permit programs, abandoned mine land reclamation, and water quality improvements in Pennsylvania and other coal mining states, it is time to re-evaluate the regulatory conditions that were originally developed, advance the process by offering new remining incentives, and remove disincentives embedded in the current remining program. The goal is to develop a more efficient remining permitting process, with design-based permit standards, that incorporates critical BMPs. The permitting incentives should be integrated with watershed-scale approaches to abandoned mine land reclamation and AMD abatement. Risk assessment protocols should be developed to minimize liability and risk concerns of mine operators, state and federal regulatory agencies, watershed groups, and landowners.

The 1998 IMCC Solicitation indicates that 7 states have issued Rahall-type permits (Refer to Table 5). Pennsylvania's remining program has issued more than 300 remining permits, accounting for 91 percent of all the Rahall permits (Figure 1). The remaining states have issued ten or less remining permits each.

Figure 1: Percentage of Total Number of Rahall Permits Issued by State



Below is a brief history of the development and requirements of each state's remining program.

Pennsylvania

Prior to the federal law changes in 1987, the Pennsylvania (PA) legislature amended PA SMCRA in 1984 (Senate Bill 1309) to include remining incentives. Under the PA law and related regulations [25 PA Code Chapter 87, Subchapter F (bituminous coal) and Chapter 88, Subchapter G (anthracite coal)] a baseline pollution load is established, a pollution abatement plan is submitted incorporating best technology, and the effluent limits for the pre-existing discharges are determined by the BPJ process. From 1984 to 1988, PA Department of Environmental Resources (PA DER), now PA Department of Environmental Protection (PA DEP), EPA, and OSMRE, were involved in a cooperative research and development project with the Pennsylvania State University and KRE Engineers concerning elements of the BPJ process. The project resulted in the development of the REMINE computer program and related publications by Smith (1988) and Pennsylvania Department Of Environmental Resources and others (1988).

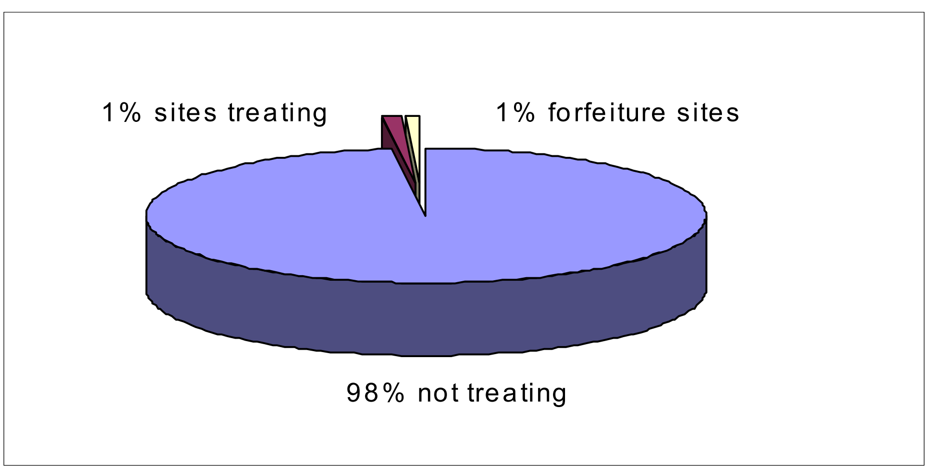
Between 1985 and June 1997, PADEP issued 260 remining permits (Table 8 and Figure 1), based on the following three-step process: (1) development of baseline loads; (2) submittal of a pollution abatement plan (technologies and BMPs); and (3) development of water quality limitations and standards based on BPJ. Of the 260 facilities issued permits, only three are required to treat pre-existing discharges on a long-term basis to achieve compliance with the baseline pollutant levels. Treatment can also be required to treat short-term excursions from the baseline. Only eleven permits (4.2 percent) have ever required treatment on a temporary or long-term basis in Pennsylvania.

An independent evaluation of the success of the PA remining program was performed by Hawkins (1995) of the U.S. Bureau of Mines. As of 1995, the Pennsylvania remining program successfully permitted for reclamation approximately 4,000 acres of abandoned mine land, which led to the production of 36 million tons of coal from acres deemed “untouchable” under pre-remining regulations (Hawkins, 1995). Site-specific data and a project description for a key remining site (Fisher Mining Company, Lycoming County) are found in publications by Plowman (1989) and Smith and Dodge (1995). The authors reported that pre-remining data from the main discharge from the Game Land site showed a medium net acidity in excess of 100 mg/L. Post-remining data showed the same discharge to be net alkaline, and the receiving stream now supports brook trout. Another independent evaluation of water quality improvements and costs of remining in Pennsylvania and West Virginia was performed by Skousen and others (1997), including data from ten sites, of which the largest and most significant is Solar mine near Pittsburgh. The water quality improved at all ten sites. In all but two cases, coal mined and sold produced a net profit for the mining company.

Table 8: Pennsylvania Remining Permits Which Required Treatment, June, 1997 (IMCC, 1997)

	Bituminous Region	Anthracite Region	Totals
Permits Issued	248	12	260
Currently Treating	3	0	3
Forfeited due to AMD	2	0	2
Required Treatment	11	0	11

Figure 2: Status of 260 Pennsylvania Remining Permits (IMCC, 1997)



Pennsylvania has taken additional steps to encourage remining and reclamation of abandoned mine lands. In 1997, SMCRA and 25 PA Code Chapter 86 were revised to authorize bonding incentives, including reclamation bond credits and financial guarantees. A qualified mine operator can earn bond credits by performing voluntary reclamation of additional mine lands. The credit is the operator's cost to reclaim the proposed area or DEP's cost, whichever is less. Credits may then be applied as bond on any coal mining permit, and may be transferred and used once after their first use.

West Virginia

West Virginia has issued eight remining permits with modified water quality requirements. The basic elements of their program are similar to those in Pennsylvania in that the applicant must conduct water quality and quantity monitoring to establish a baseline pollutant load and must submit an abatement plan.

In order to receive remining approval, operators must demonstrate that their proposed abatement plan represents the best available technology and that the operation will not cause additional surface water pollution and will result in the potential for improved water quality. Effluent limits in the remining permit do not allow a discharge of pollutants in excess of the baseline pollutant load. Also, a remining water quality standard variance must be approved prior to issuing the National Pollutant Discharge Elimination System (NPDES) remining permit. If the variance is denied, the NPDES Remining Permit will also be denied.

Maryland

Although Maryland has a relatively small coal industry, the State actively implemented the Rahall Amendment, which allows for a modified NPDES permit for remining operations. Maryland also implemented EPA revegetation standards allowing for bond release after 2 years, and offers reduced bonding rates for an NPDES remining permit. Currently, Maryland has issued two remining permits with relaxed effluent limits. Maryland has numerous remining operations on previously mined areas with no pre-existing discharges.

Virginia

Virginia has regulations for remining and has issued three permits with relaxed effluent limits for remining operations. Operators must show that remining operations have the potential to improve water quality. To obtain a remining permit, the applicant submits baseline monitoring data, a module of REMINE, and an abatement and reclamation plan. Permits are based on BPJ determined by the output of REMINE and must result in a reduction in pollutant loading to the stream.

Kentucky

Kentucky has regulations for remining and has issued four permits with relaxed effluent limits for remining activities. The Kentucky procedure is much like that described for the other states above. The applicant submits baseline monitoring data, an abatement and reclamation plan, and may submit a module of REMINE. Operators must show that remining operations have the potential to improve water quality. Permit limits are based on BPJ and must result in a reduction in pollutant loading to the stream (Veil, 1993).

Tennessee

Tennessee does not administer its coal mining program. OSMRE maintains the authority to issue coal mining permits. As of 1993, about 60 percent of all coal mining permits in the state involved remining, however, no permits were issued with relaxed effluent limits.

Ohio

Ohio has regulations for remining and has issued three permits with relaxed effluent limits for remining activities. Remining approvals are limited to sites with pre-existing discharges. Operators must submit baseline monitoring data along with a pollution abatement plan and supplemental hydrological information. Permit approval is contingent on the abatement plan representing BAT and having the potential to reduce the baseline pollutant load (Veil, 1993).

Alabama

Alabama has issued 10 permits with relaxed effluent limits for remining operations. To qualify for a remining permit an operator must show:

- Original mining/disturbance must have occurred prior to 1977.
- Subsequent permitted/legal disturbance could not have occurred after 1977.
- Areas that have had a SMCRA permit or bonding at any time are not eligible.
- Substantive showing must be made that water quality can be improved (a pollution abatement plan must be submitted).
- Effluent limits must at least meet ambient water quality standards.

Modified requirements for pH, iron and manganese must apply the best available technology economically achievable on a case-by-case basis, using best professional judgement, to set specific numerical effluent limits in each permit.

Regulatory agencies for states where remining is not currently practiced may be inclined to start and promote remining programs if such programs can be shown to be successful in terms of enhanced coal recovery, reclamation of abandoned mine lands, and reduction of (or no net increase in) mine drainage. Mine operators also may be more inclined to enter into remining projects with the knowledge that the potential of incurring liability for long-term treatment of mine waters from prior mining activities is low.

Introduction to Best Management Practices

Remining is the mining of abandoned surface mines, underground mines, and/or coal refuse piles that were mined prior to the environmental standards imposed by the Surface Mining Control and Reclamation Act of 1977. There are four types of abandoned mine lands available for remining operations: (1) sites that were previously surface mined, (2) sites that were previously underground mined, (3) sites that were previously surface mined and underground mined, and (4) sites that had coal refuse deposited on the surface. These sites were typically left unreclaimed and unvegetated, sometimes pose safety hazards, and are often associated with pollutional discharges or sedimentation problems. Because of associated environmental problems, these areas cannot be re-affected or remined without the implementation of minimal best management practices (BMPs) in an attempt to correct past problems.

BMPs implemented during the remining and reclamation of these sites are designed to reduce, if not completely eliminate, pre-existing environmental problems, particularly water pollution. The types and scope of BMPs are tailored to specific operations based largely on pre-existing site conditions, hydrology, and geology. BMPs are designed to function in a physical and/or geochemical manner to reduce the pollution loadings.

In this guidance document, BMPs have been placed into four categories: hydrologic and sediment control, geochemical, operational, and passive treatment, although there is some question whether passive treatment is a true BMP. These categories have been designed for ease of discussion, and each BMP has been placed in the category that is most appropriate. In several cases, a BMP serves more than a single function. For example, induced alkaline recharge trenches are discussed as a geochemical BMP, but they also influence hydrology and are closely related to some passive systems. Adding to this complexity is the fact that remining operations nearly always employ multiple BMPs in an effort to abate pollution.

Physically performing BMPs function to limit the amount of ground water that is ultimately discharged from the mine and by reducing erosion and subsequent off-site sedimentation by controlling surface-water runoff. Discharge reduction is performed by limiting the amount of ground water and surface water that laterally or vertically infiltrates into the backfill. Water is routed away from spoil via regrading, diversion ditches, low-permeability seals and caps, and highwall and pit floor drains. Ground water that has entered the spoil is collected and drained away via floor drains. Some physical BMPs are performed to reduce ground-water flow, some to reduce erosion and sedimentation problems, and some serve both purposes. Physical BMPs are addressed in Section 1.0 (Hydrologic and Sediment Control Best Management Practices). Below is a list of physically performing BMPs and an indication of whether they influence ground-water hydrology (gw), erosion and sedimentation (e&s) or both (gw, e&s).

- Regrading of spoil (gw, e&s)
- Revegetation (gw, e&s)
- Diversion ditch installation (gw, e&s)
- Installation of low-permeability caps (gw)
- Stream sealing (gw)
- Underground mine daylighting (gw)
- Mine entry and auger hole sealing (gw)
- Highwall and pit floor drains (gw)
- Grout curtains (gw)
- Ground water diversion wells (gw)
- Advanced erosion and sedimentation controls (e&s)

Geochemically performing BMPs function to inhibit pyrite oxidation, reduce the contact of water with acid-producing materials, inhibit iron-oxidizing bacteria, or increase the amount of alkalinity generated within the backfill. Pyrite oxidation is inhibited by limiting its exposure to the atmosphere and preventing the proliferation of iron-oxidizing bacteria with bactericides. Acidic materials are specially handled or capped to isolate them from the ground-water flow path. Alkaline materials are imported, redistributed, and strategically placed in the ground-water flow path in order to increase and/or accelerate alkalinity production. Geochemical BMPs are discussed in Section 2.0 (Geochemical Best Management Practices). Geochemically performing BMPs include:

- Alkaline addition
- Alkaline redistribution
- Mining into highly-alkaline strata
- Induced alkaline recharge
- Special handling of acid-forming materials
- Special handling alkaline materials
- Use of bactericides

Operational BMPs are mining practices that can reduce the risk of pollution, erosion, and sedimentation problems. Rapid mining and concurrent reclamation limit the exposure of acid-forming materials to weathering and promote rapid reclamation and revegetation that can reduce erosion and sedimentation problems. Coal refuse reprocessing removes an acid-producing material. This material is burned to produce electricity, and the ash that is produced, which is frequently alkaline, is returned to the site where it can neutralize acid. Operational BMPs are discussed in Section 3.0 (Operational Best Management Practices). They include:

C Coal refuse reprocessing
C Rapid mining and concurrent reclamation
C Limited or no auger mining
C Off-site disposal of acid-forming coal cleanings, pit and tipple refuse

The last category, passive treatment technologies, encompasses a variety of engineered treatment facilities that require minimal maintenance, once constructed and operational. Passive treatment generally involves natural physical, biological, and geochemical actions and reactions. The systems are commonly powered by water pressure created by differences in elevation between the mine discharge point and the treatment facilities. Passive treatments do not meet the standard definition of BMPs in that they are typically end-of-pipe (treatment) solutions. They are included in this manual because they can be used as part of the overall abatement plan to reduce pollution loads discharging from remining sites. Passive treatment methods are discussed in Section 4.0 (Passive Treatment Technologies). Types of passive treatment include:

- Anoxic limestone drains
- Constructed wetlands
- Successive alkalinity-producing systems
- Open limestone channels
- Oxic limestone drains
- Alkalinity-producing diversion wells
- Pyrolusite® systems

Site Characteristics and BMP Selection

Factors that influence which BMPs can be employed effectively at remining sites include previous types of mining activities, geologic and hydrologic characteristics of the site, the quality and quantity of pre-existing discharges, economics, and regional differences. Listed below under these categories are examples of associated BMPs and some of their limitations.

Previous mining history

- Daylighting only occurs where previous underground mining was conducted.
- Mine sealing is used where underground mines or auger holes are not completely daylighted.
- Regrading and revegetation are performed on abandoned and reclaimed surface mines.
- Coal refuse reprocessing occurs where there are abandoned coal refuse piles.

Geologic and hydrologic characteristics

- Alkaline addition is conducted where there is an inadequate quantity of naturally-occurring alkaline rocks.
- Alkaline redistribution takes place where only a portion of the site has a significant amount of alkaline material which is then distributed more evenly across the site.

- Alkaline material that is located stratigraphically high above the coal may require mining into higher cover to access it or may require a reorientation of the pit so that the alkaline material is encountered with every mining cut.
- Special handling of acidic material occurs where there is a significant amount, but not an over-abundance, of this material that can be field-identified and segregated.
- Highwall drains are not an option where no up-gradient final highwall remains.
- Hydrologic controls, such as floor drains or ground-water diversion wells, are not necessary unless lateral recharge is present.
- The site may be capped with a low-permeability material, if vertical recharge is predicted to be the main source of water to the backfill and a low-permeability material is readily available.
- Passive treatment may be used, if the topography to drive the system is present and sufficient construction space is available.

Pre-remining water quality and quantity

- Large volumes of severely degraded water may not be suitable for a passive treatment BMP.
- High volumes of water flowing from underground mines that will not be completely daylighted may be suited to rerouting (piping) through the spoil.
- Highly acidic pre-remining discharges associated with pyritic overburden may require substantial alkaline addition and/or special materials handling.

Economics

Cost plays a substantial role in determination of which BMPs are employed and the degree to which they are implemented. Remining sites are commonly economically marginal because of reduced coal recovery rates compared to virgin sites. These sites also generally entail greater reclamation costs due to pre-existing site conditions. Therefore, economics plays a significant role in the development of a BMP plan. The BMP plan is weighed against these costs. If the cost of BMP implementation is prohibitive the site will not be remined. Mining only occurs on sites where a profit can be made.

Regional Differences

There are also regional considerations that play into the decision of which BMPs to use at a particular site. Differences in the geology, geochemistry, hydrology, and topography between coal regions cause distinct problems requiring differing solutions. Regional differences include:

- Geologic conditions that effect the type (lithology), chemistry/mineralogy, and the structure (e.g., folding, faulting, and fracturing) of rocks.
- Hydrologic conditions, such as differences in local and regional ground-water flow systems and precipitation amounts, frequency, and/or duration.
- Differences in topography (such as amount of relief and steepness of slopes).
- Differing surface and underground mining techniques, thus abandoned sites will exhibit distinct problems regionally.

Acid Mine Drainage

It has been recognized for decades that acid mine drainage (AMD) is to a large extent a regional problem that is most prevalent in the northern Appalachians. Upon closer examination it was evident that the problem was frequently associated with the Allegheny Group coals (Appalachian Regional Commission, 1969). Figure 3 illustrates the percentage of streams within various Appalachian watersheds that had pH less than 6.0. Figure 4 shows the percentage of streams for these same watersheds that have sulfate greater than 75 mg/L. The cut-offs of pH 6.0 and 75 mg/L sulfate were chosen by the US Geological Survey because low pH and elevated sulfate can indicate impacts from coal mine drainage.

Watersheds with 35 percent or more of streams with pH less than 6.0 occur in the northern Appalachians and are associated with the outcrop areas of the Allegheny Group. Typically the watersheds in the southern Appalachians have 10 percent or less of steams with pH less than 6.0.

The distribution of watersheds with a high percentage of streams with greater than 75 mg/L sulfate does not necessarily correspond with the low pH areas. For example, one of the watersheds in eastern Kentucky had 57 percent of streams with sulfate greater than 75 mg/L, but no stream measured had pH less than 6.0. Other watersheds show similarly high percentages of streams with sulfate greater than 75 mg/L, but with few streams with pH less than 6.0. This type of water is characteristic of neutralized acid mine drainage.

No full explanation of the water quality differences within the Appalachian Basin has been provided to date, but there is little question that it is due to geologic differences. Cecil and others (1985) examined sulfur data for coals from southern West Virginia to Pennsylvania. The stratigraphically older coals, which occur in southern West Virginia, have lower sulfur than the younger coals that occur in the northern Appalachians (Figure 5). Cecil and others attribute these differences to climatic factors at the time of peat (coal) deposition that influenced the chemistry of the swamp, which ultimately influenced the sulfur content of the coal.

The production of acidity from pyritic sulfur is only half the story. The other half of the story is the production of alkalinity from carbonate dissolution. Calcareous rocks neutralize acid and they are the explanation for the water quality in streams that have pH greater than 6.0 and sulfate greater than 75 mg/L (i.e., neutralized mine drainage).

It is evident that in some regions AMD is a significant problem, while in other areas it is rare. This difference is an important factor in remining. Where AMD is prevalent, water quality is an important remining issue. Where AMD is rare, water quality typically less of a concern, with the possible exception of sedimentation problems.

Figure 3: Percentage of Streams with pH < 6.0 for 24 Watersheds in the Appalachian Basin (data from Wetzel and Hoffman, 1983).

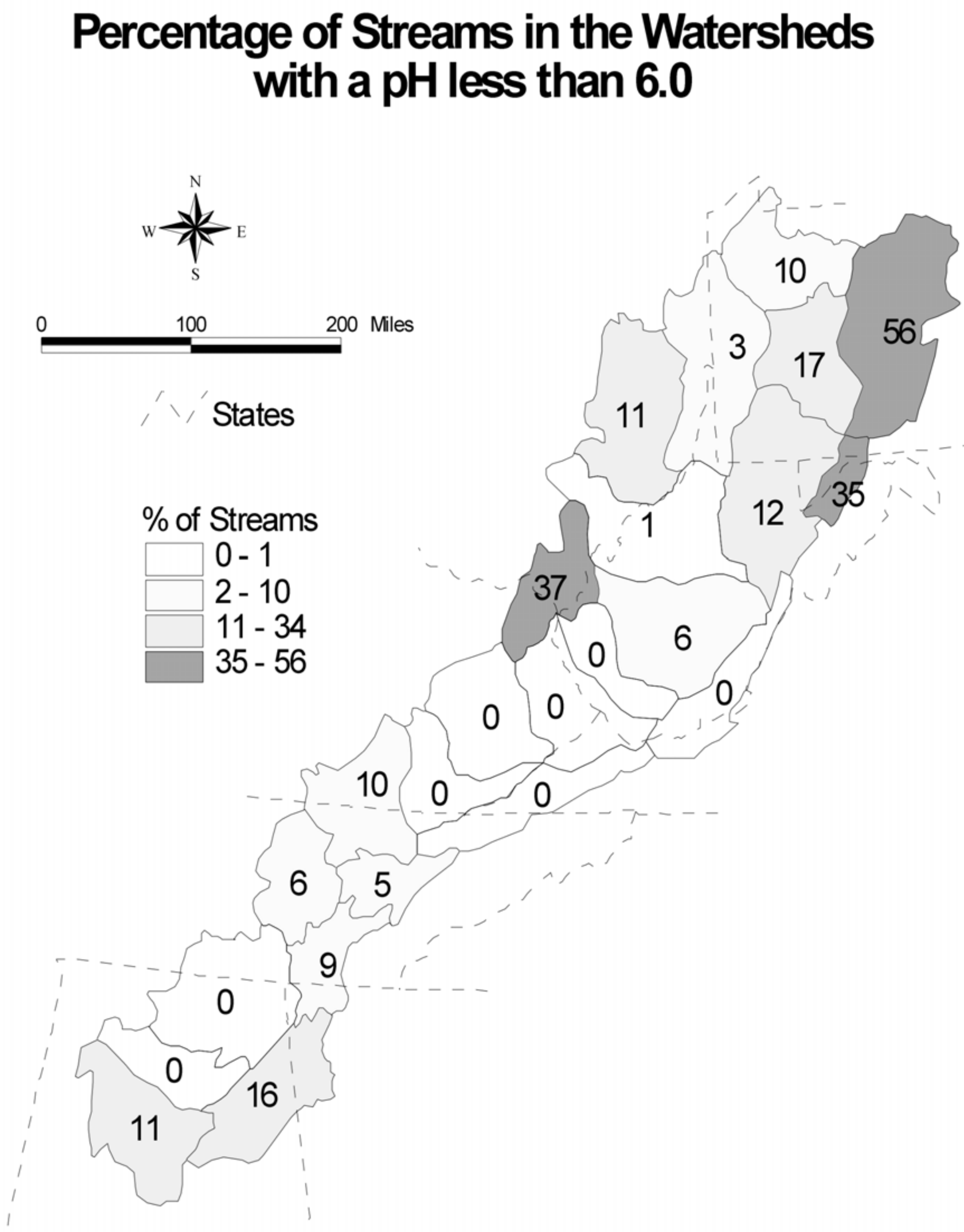


Figure 4: Percentage of Surface Water Sample Stations with Sulfate Greater than 75 mg/L for 24 Watersheds in the Appalachian Basin (data from Wetzel and Hoffman, 1983).

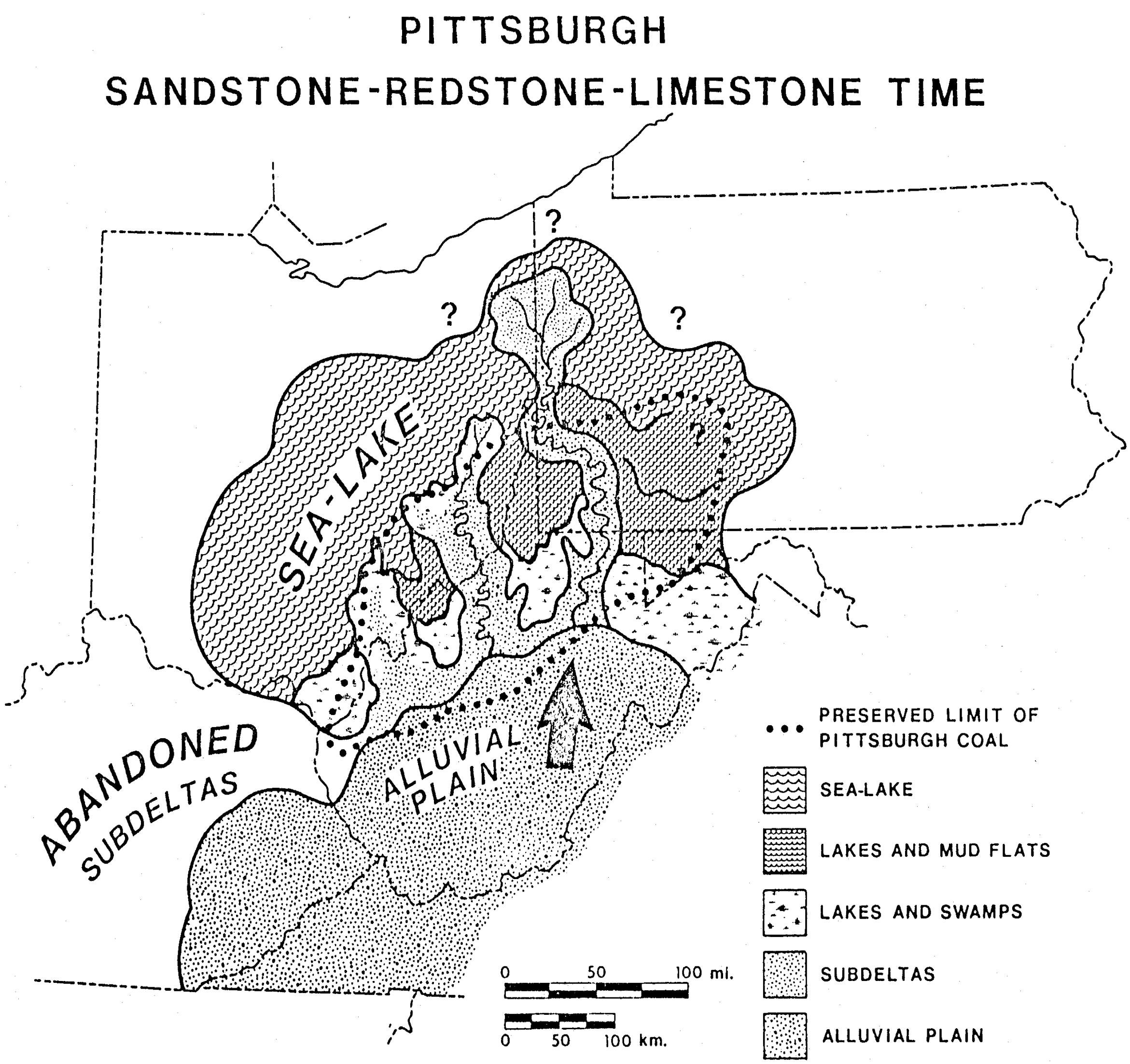
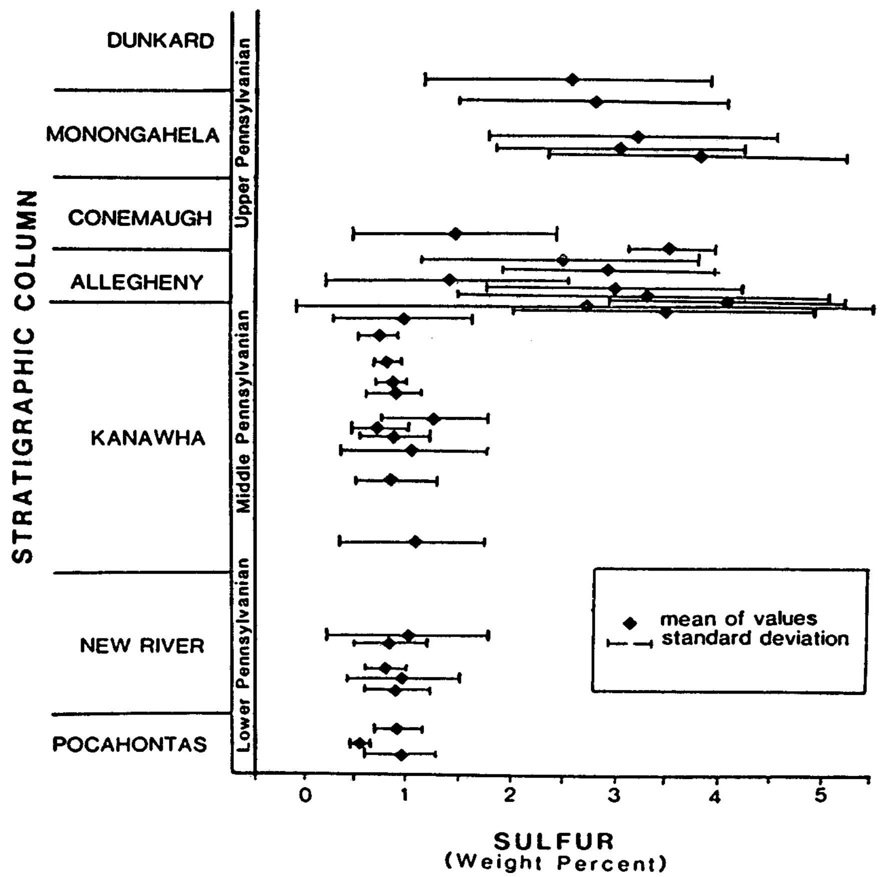


Figure 5: Stratigraphic Variation of Sulfur Content of 34 Coal Beds of the Central Appalachians (Figure from Cecil and others, 1985).



Hydrology

The ground-water hydrology is similar throughout much of the Appalachian Plateau, however there are some subtle differences between regions. Some of these differences are related to changes in major rock types associated with the coal which in turn directly impacts the fracturing density, interconnectedness of fractures, depth of fracturing, and aperture size of the fractures. For example, experience has shown that in shallow cover (# 200 ft), the massive, well-cemented sandstones commonly associated with coals of eastern Kentucky tend to exhibit much less fracturing than is observed in the more thinly-bedded, poorly-cemented sandstones associated with the Pittsburgh coal in northern West Virginia. These differences will be reflected in the ground-water flow systems (location of ground water, amounts in storage, and ground water movement velocity) of the respective areas.

Additionally, the ground-water systems associated with the mid-western coals in Indiana and Illinois are primarily regional in nature and near surface, whereas ground-water systems in the Appalachian Plateau are characterized by a series of limited-area perched aquifers underlain by deeper more regional systems that discharge to the major rivers and creeks of the area (e.g., Monongahela, Kanawha, or Tug Fork rivers).

Topography and Geomorphology

Regional differences in topography and geomorphology can impact the types of BMPs employed. For example, the topography of southern West Virginia, western Virginia, and eastern Kentucky is generally steep with narrow V-shaped valleys and sharp-peaked hills and mountains. Figure 6 shows this type of topography in Kanawha and Raleigh Counties in southern West Virginia. The topography of northern West Virginia and western Pennsylvania is not nearly as steep-sloped, with broader valleys and more flat-topped hills and mountains. Figure 7 illustrates this topography in Jefferson County in west-central Pennsylvania. These differences have resulted in distinctive mining techniques and post-mining configurations. For example, the steep sloped areas tended to promote contour surface mining (Figure 8), whereas in shallower sloped areas, block cut or area mining was used more frequently (Figure 9).

Mining Methodology

Differences in mining methods can result in greatly differing abandoned mine site conditions, and thus may require distinct BMP engineering plans to effect water quality improvement. For example, the steep-sloped areas may require additional ditches, check dams and ponds for stabilizing, while regrading and revegetating a shallower sloped area may be adequate to stabilize erosion. Abandoned mines in southern West Virginia, western Virginia, and eastern Kentucky frequently exhibit down-slope spoil disposal, open pits, and exposed highwalls making reclamation back to the approximate original contour (AOC) impractical in most cases. Abandoned mines in northern West Virginia and western Pennsylvania often have some open pits and exposed highwalls, but they are commonly characterized by a series of unreclaimed spoil piles and ridges. Returning the site to AOC is generally more feasible on these sites. The “shoot and shove” method of past mining on the steep slopes of the central Appalachian Plateau has resulted in erosion and sedimentation problems.

Figure 6: Example of Steep Topography and High Relief in Southern West Virginia Showing Multiple Contour Strip Mines on Steep Slopes.

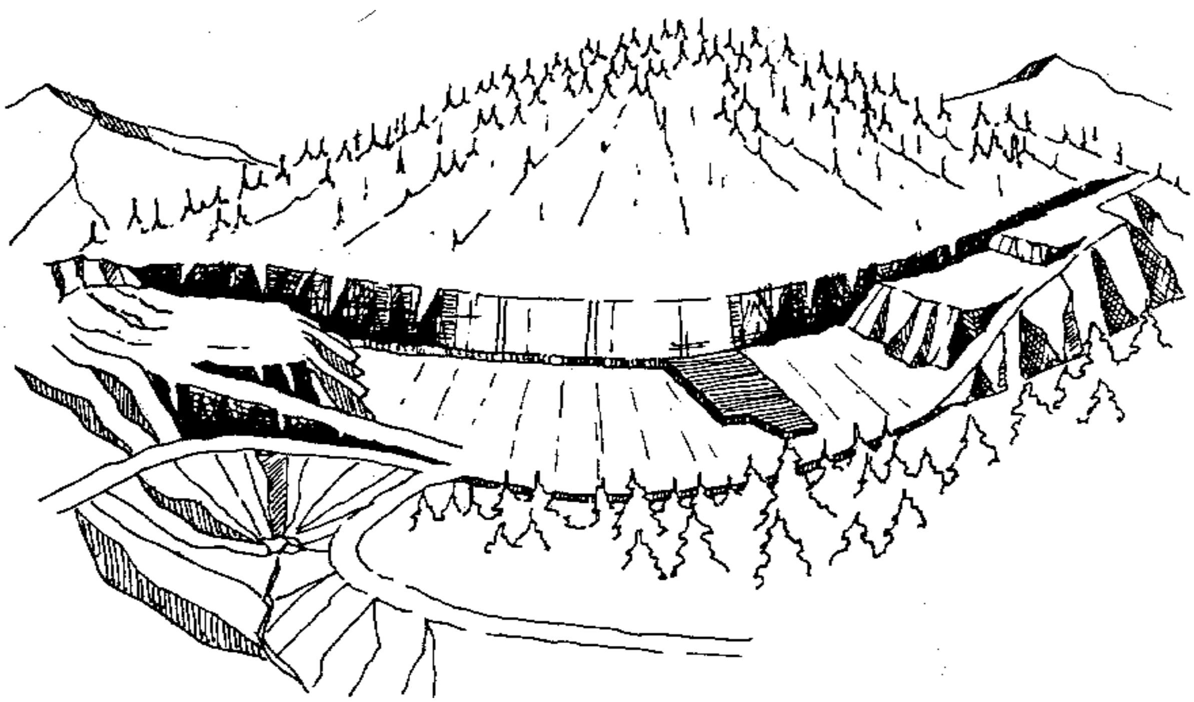


Figure 7: Example of Moderate Slopes and Broader Valleys and Hilltops in West-central Pennsylvania Showing Small Area Mines.

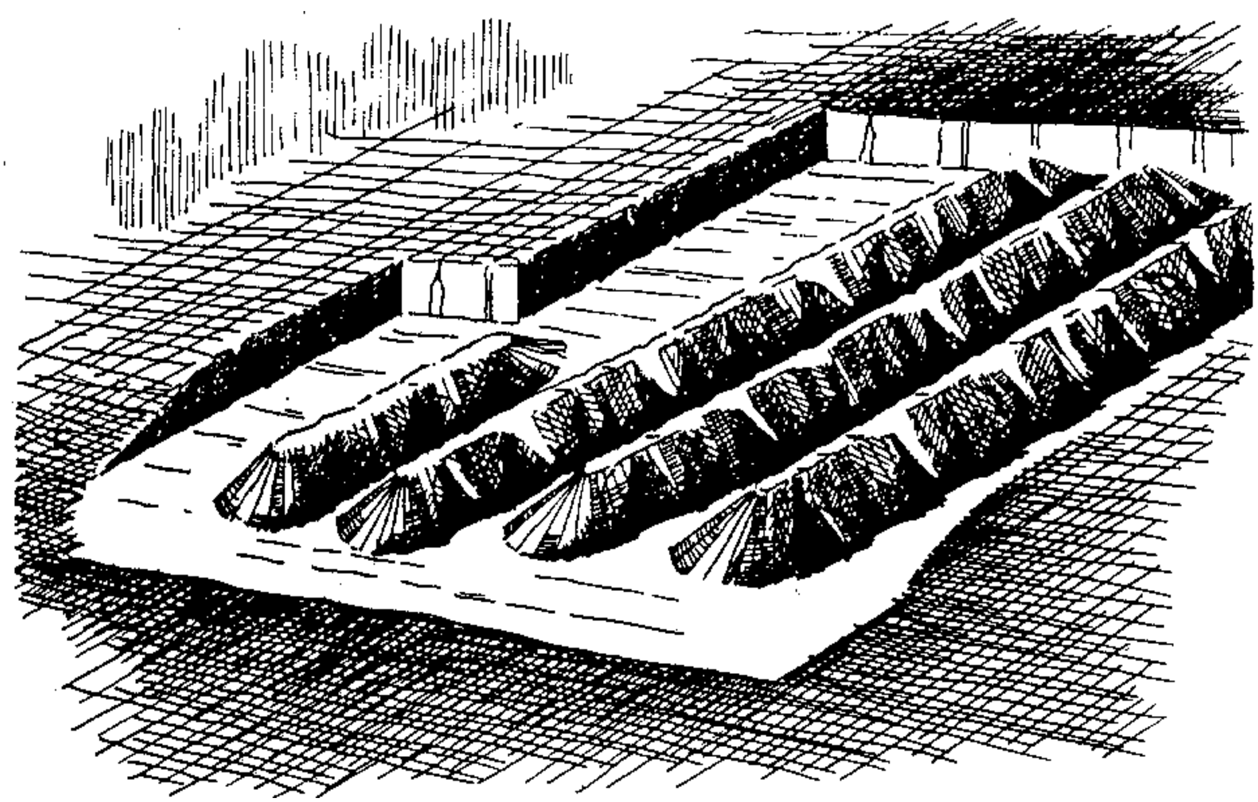


Figure 8: Topographic Map Illustrating Contour Surface Mining.

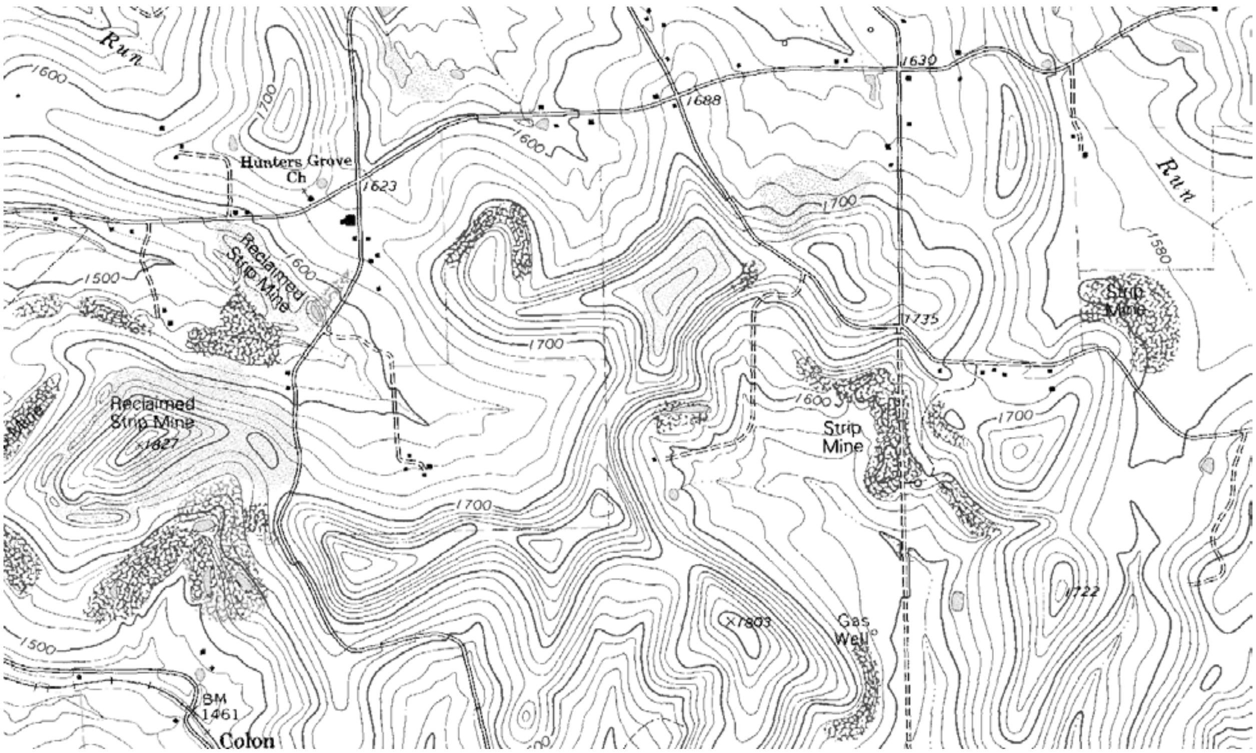
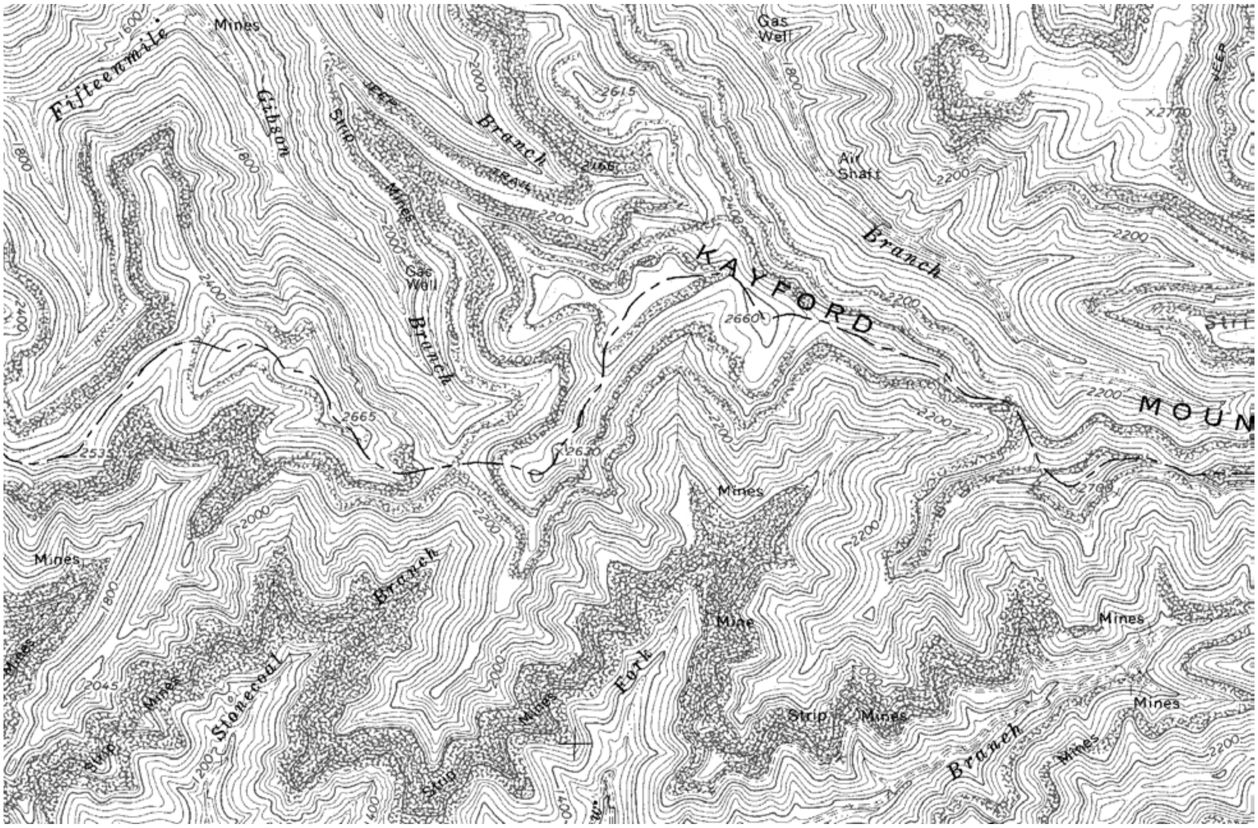


Figure 9: Topographic Map Illustrating Area Surface Mining.



BMP Implementation

The best BMP plan may fail if it is not implemented as designed (e.g., conducted properly, adequately, and on a timely basis) and as approved by the permitting authority. To facilitate field implementation, the BMP plan should be clearly thought out and designed for site-specific conditions during the permit application process. A well-designed plan can eliminate the need for revisions once the permit is issued and will provide guidance to ensure proper implementation. However, a well-designed plan also provides a degree of flexibility to allow for "mid-stream" changes caused by unforeseen circumstances.

An effective BMP plan hinges greatly on a detailed site assessment. Site assessment data and information should be sufficient to identify which strata will require handling, potential sources of ground water, probable reasons for existing AMD, the scope of previous mining, and other salient data. Site assessment will typically, at a minimum, require extensive field work and mapping, multiple bore holes with appropriate vertical sampling, ground-water level measurements, surface water flow measurements, and representative ground- and surface-water samples.

A BMP plan should be realistic. It should be appropriate to the site, workable in the field, economically feasible, and based on sound scientific principles. Plans should be clearly designed with appropriate maps, cross-sections and narrative. The ultimate viability of a BMP plan depends heavily on the individual(s) that develops the BMP plan, the one(s) that review and approve it, those who implement it, and those who enforce it. The BMP plan should be verifiable and enforceable by those individuals who inspect the site. Implementation guidelines are provided for each category of BMPs in the appropriate sections.

Efficiency

The efficiencies of BMPs or groups of BMPs, with regard to decreasing pollution loadings, are based on limiting one or more of the following factors:

- C Amount of pyritic material
- C Availability of oxygen to the pyritic material
- C Contact of water with the pyritic material

Previous studies (Smith, 1988; Hawkins, 1995) have shown that controlling (decreasing) the flow of AMD discharges exerts the largest influence on the reduction of pollution load. Flow reduction is best accomplished by reducing surface- and ground-water infiltration. However, prevention of additional acid formation by use of geochemically based BMPs can also decrease the pollutant concentration which will likewise decrease the associated loading. BMPs can also function by treatment (neutralization) of AMD after it has formed. This treatment can be *in situ* neutralization from contact with additional alkaline materials or can be in the form of end-of-the-pipe treatment performed by passive treatment systems.

Some BMPs function in more than one way. Underground mine sealing will not only inhibit ground-water movement, it will also attenuate oxygen infiltration. Alkaline addition can prevent AMD through inhibition of iron-oxidizing bacteria, and it can neutralize acidity once it has been produced. Surface- and ground-water controls can reduce erosion and sedimentation, while inhibiting infiltration into the spoil.

Efficiencies of BMPs are discussed in the sections dealing with each BMP category and are evaluated through observations and the statistical approaches described in Section 6.0 (Efficiencies of Best Management Practices).

Verification

Proper implementation of BMPs can be critical to the environmental success or failure of a remining site. Thus, it is imperative that the BMPs be implemented as planned. It is the role of the regulatory inspection staff to verify and enforce the provisions outlined in the BMP plan of a remining permit. In general, the inspector does not need to be present at all times to assess the implementation of the BMPs in this document. However, some BMPs will require more detailed and more frequent inspections than others. It is also incumbent on the mine operator to ensure that the BMPs are implemented as designed and to provide the proper documentation (e.g., material weigh slips, receipts, laboratory analyses, etc.) where necessary. Guidelines for verification for each BMP category are provided in the appropriate section of this manual.

Monitoring of the water quality and quantity is the truest measure of BMP effectiveness. If the discharges exhibit lower pollution loadings, it is an indication that the BMPs were successful with all other factors being equal.

Monitoring and inspection of BMPs to verify site conditions and implementation should be a requirement of any remining operation. Verification includes:

- Direct measurement of flow and water sampling for contaminant concentrations before, during, and after reclamation;
- Continuation of monitoring beyond the initial water table re-establishment period (e.g., at least two years after backfilling);
- Evaluation of water quality and quantity data at hydrologically connected units and/or discrete individual discharges, so trends caused by remining can be assessed;
- Review of hydrologic data with respect to climatic (i.e. precipitation) conditions;
- Assessment of deviations from the approved implementation plan.;
- Inspection of critical stages of the BMP implementation plan, such as during special materials handling, alkaline addition, drain installation, or mine entry sealing;
- Inspection to assure that proper maintenance is performed where required;
- Review of material weigh slips, receipts, laboratory analysis, and other necessary documentation;
- Assessment of BMP stability over time;
- Periodic site evaluation to ensure the BMP plan is appropriate to on-site conditions. This evaluation should include, at a minimum, assessment of water quality and quantity, site physical and geologic conditions, and impacts of significant storm events.

Adequate inspection and verification are necessary to ensure that BMPs are being performed as proposed. Remining operation inspections will also provide information as to changing site conditions (anticipated and unanticipated) as well as unexpected developments.

Verification also will provide additional data for on-going assessment of the efficiency of individual BMPs as well as BMP combinations. The analyses of these data will foster continuing improvement of the BMPs which will ultimately lead to more efficient ways of decreasing pollution loadings.

This manual is designed to:

- Describe the BMPs that are available for remining operations;
- Define the appropriate circumstances for the BMPs;
- Explain how each BMP functions to diminish the pollution load;
- Discuss how a BMP works or in conjunction with other BMPs;
- Give details of BMP construction and installation specifics, size and scope of a particular BMP, and the required materials;
- Present actual data from remining case studies employing various BMPs;
- Discuss relative frequency of use for each BMP;
- Give estimates of the cost of employing each BMP; and
- Present projected efficiencies of specific BMPs based on a database of 116 completed sites in Pennsylvania, case studies, and published research.

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